METHOD TO EQUALIZE HEAT DISTRIBUTION IN A REACTOR TUBE

Field of the Invention

The invention is to a process to equalize heat distribution in reactor tubes containing catalyst.

Background of the Invention

Isothermic tube reactors loaded with catalyst are limited in performance by heat transfer in the catalyst-loaded tubes. For endothermic reactions, heat is removed from the center of the tube, making the tube wall temperature substantially higher than the temperature at the tube center. For exothermic reactions, the heat of the reaction causes the catalyst in the center zone of the catalyst bed to be substantially higher in temperature than the outside regions of the catalyst bed near the tube wall. The temperature differential may have various adverse affects. The cool portion of a load may remain too cool for effective catalytic processing and the hot portion of a load may have a shorter than anticipated life center. In all instances the processing efficiency is sacrificed.

Heat transfer problems make isothermic reactors less efficient and less commercially attractive than adiabatic systems. This is especially true in endothermic systems, where high tube wall temperatures are needed in isothermic reactors to get sufficient heat to the center of the tubes, resulting in high temperature gradients and non-optimal performance.

Summary of the Invention

Use of catalytic monoliths allow heat to be directed in the desired direction(s), reducing heat gradients and increasing efficiency and catalyst performance. There is provided a method for equalizing heat distribution across a catalyst in a tube reactor comprising loading each tube of the tube reactor with one or more catalytic monoliths.

Detailed Description

By "monolith catalysts" is meant catalyst with ceramic supports having uni- or multi-directional channels. One or more catalytically reactive metals may be impregnated on the support, or the support material itself may be catalytically reactive. Monolith catalysts have an advantage of being able to be formed to a shape which approximates the shape of the container. Thus monolith catalysts for tube reactors may be quite long (inches to feet in length) and cylindrical in shape, typically of a diameter just smaller than the inner diameter of the tube in which the monolith catalyst will be placed. Uni- or multi-directional channels may be molded into the monoliths to direct the flow of feed as desired. In this manner, each individual channel is equivalent in surface area to many loose catalyst particles.

The surfaces of the channels are impregnated with catalytically reactive metals or metal compounds, making each channel effective as a catalyst having a surface area equal to the surface area of the channel. Or alternatively, the monolith may be made of a catalytically reactive material.

The heat distribution across the catalyst in a tube reactor is equalized by directing the heat as desired down the channels of the monolith catalysts loaded in the tubes of tube reactors. Heat may be directed inwardly, to equalize the temperature profile across the tube of an endothermic reactor, or outwardly, to equalize the temperature profile across the tubes of an exothermic reactor.

Monolith catalysts used as described have the additional advantage of reducing pressure drop through the catalyst bed.

A particular use of the process occurs in commercial isothermal reactors for styrene production by dehydrogenation of ethyl benzene, an endothermic reaction. These type reactors are plagued by three main problems:

- Low liquid hourly space velocities are required for the reaction, making large diameter tubes necessary. Since the styrene reaction is endothermic heat must be added and the larger tubes increase the temperature differentials from the outside of the tube to the center of the catalyst bed, resulting in poor catalyst performance. Further, as the tube wall temperatures are increased to try and drive heat to the center of the load, the temperatures at the tube walls may reach a level in which cracking of the ethyl benzene and styrene may occur, resulting in undesirable by-products.

- Tubular isothermal reactors have inherently high pressure drops in comparison to radial flow adiabatic reactors. This places the tubular reactors at an activity and selectivity disadvantage.

- One (1) mole of feed (ethyl benzene) becomes two (2) moles of product (styrene + hydrogen), exasperating the above described problems.

Use of monolith catalysts allow heat to be directed to the center of the catalyst bed in each tube, reducing tube wall temperatures and cracking of the feed and product to undesirable by-products. Also, the pressure drop achieved favors the styrene reaction.

The monolith catalysts thus described are useful to control the tubular temperature profile of other endothermic reactions, such as dehydrogenation processes and olefin cracking processes. The monolith catalysts may also be modified such that the channels direct heat away from the center of the reactor tubes, thus making them useful for exothermic reactions, such as the vapor phase production of epoxides and other oxygenation processes, and hydrocracking processes.

It will be apparent to one of ordinary skill in the art that many changes and modifications may be made to the

invention without departing from its spirit or scope as set forth herein.